DØ High Voltage System Tutorial

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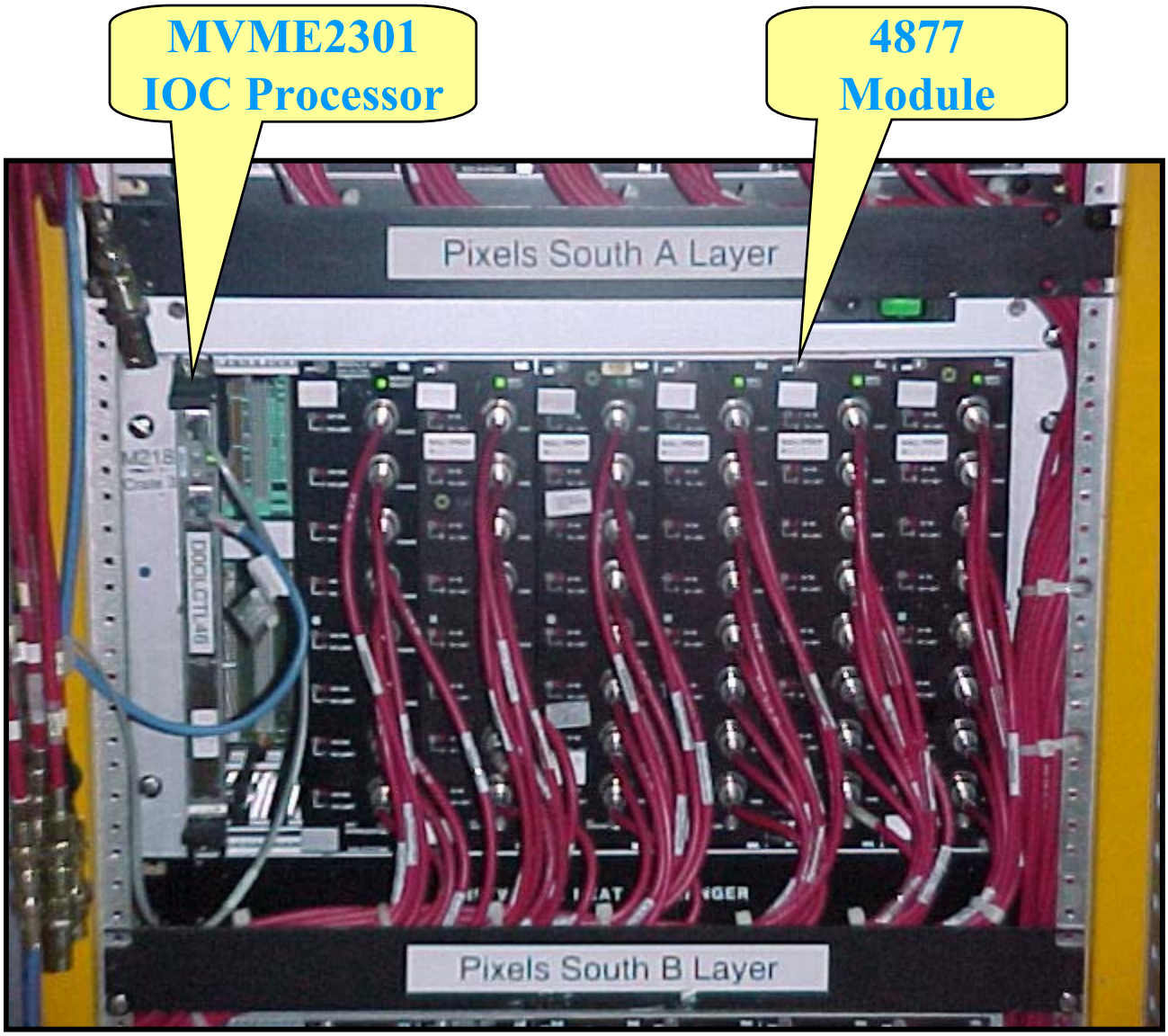
Outline

- Hardware
- EPICS Support
  - HV Record
  - HV Alarms
- Operator GUI Programs
  - HV Utility Display
  - Global HV Display
  - HV Channel Display
- Diagnostic Guidelines

- Ref:
  - \\D0server4\projects\Online_Computing\Tutorials\HvTutorial.ppt

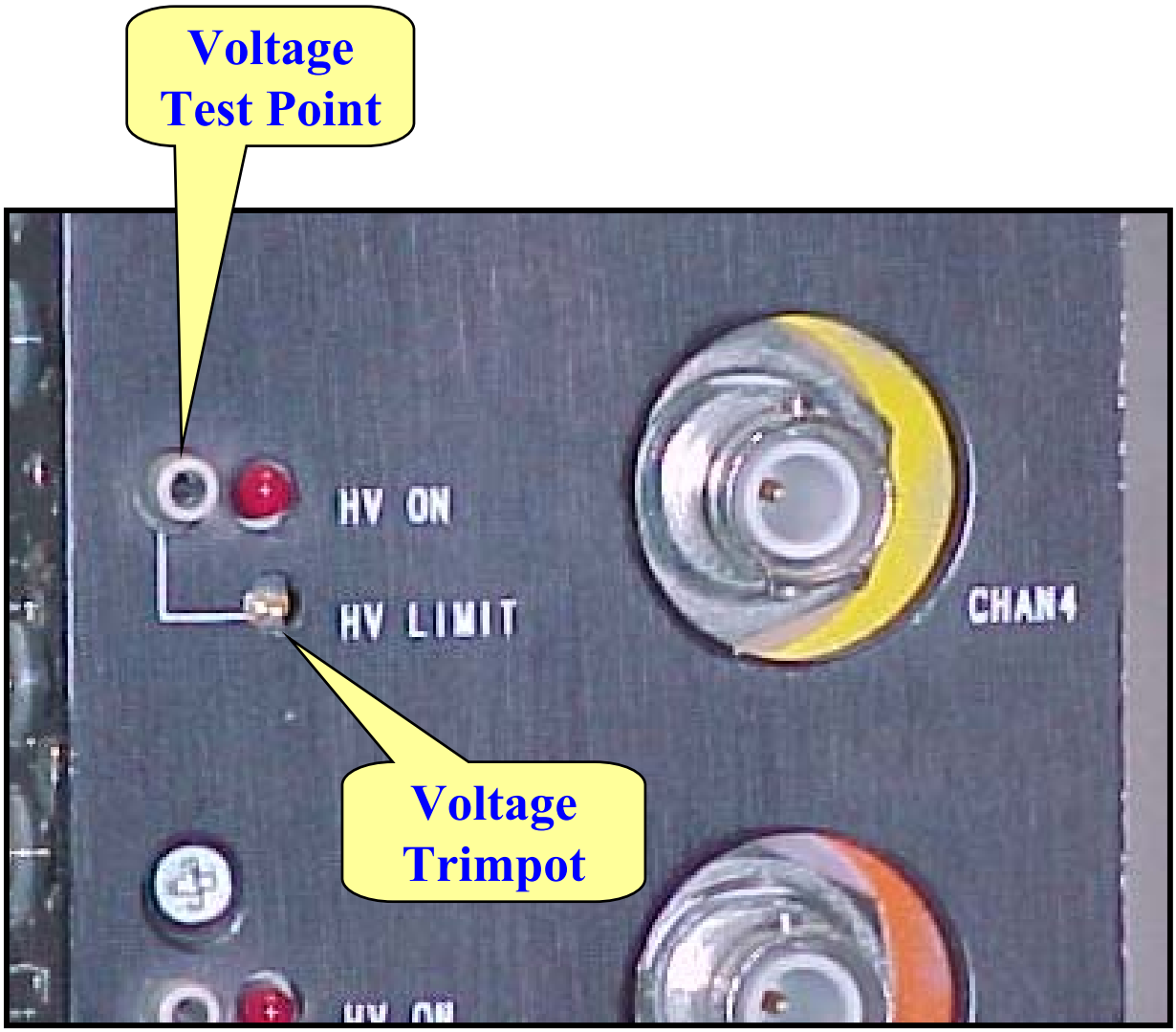
Hardware - HV Crate



Hardware - HV Module

January 22, 2003

Hardware - HV Channel



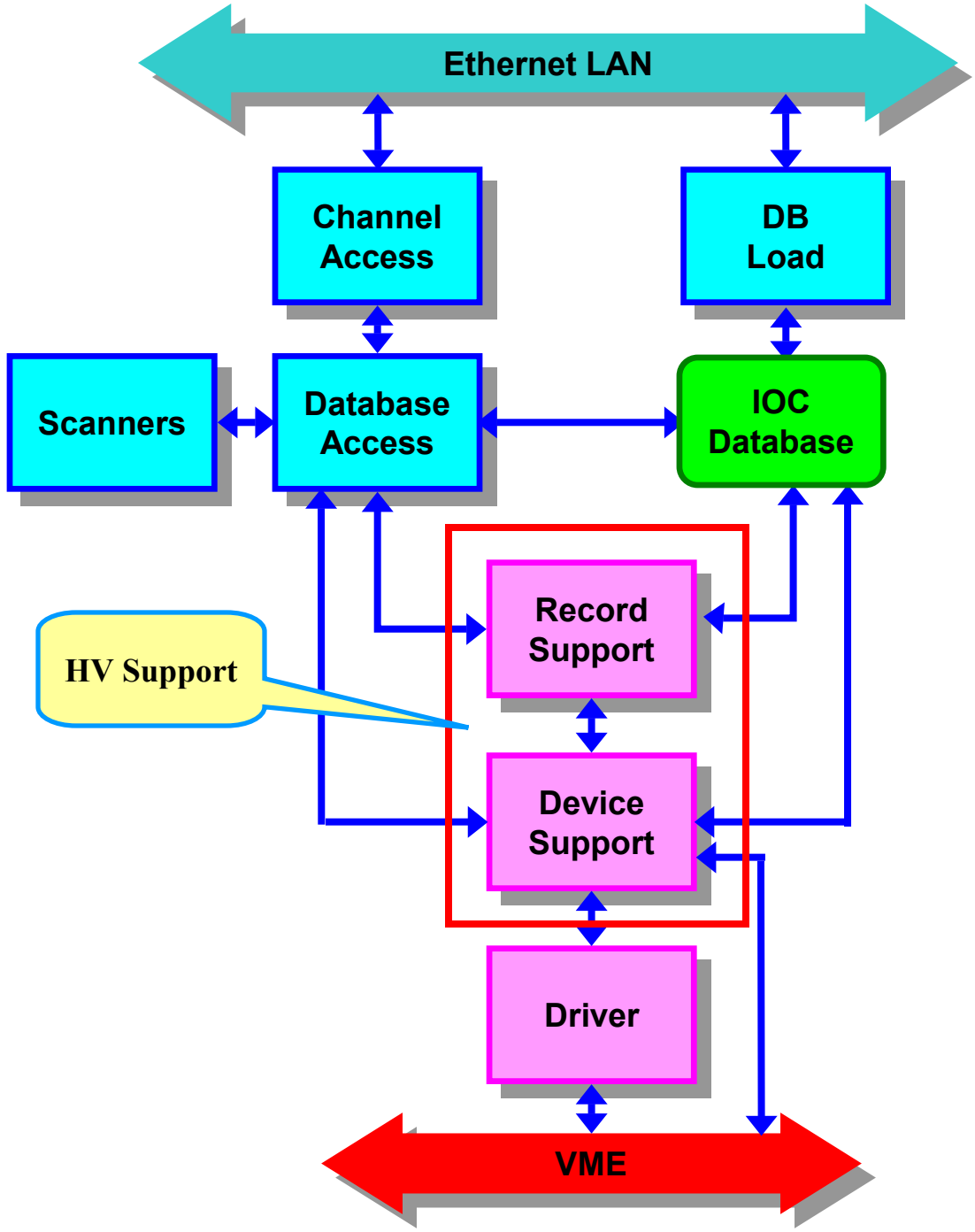
Hardware

- VME crate
  - 6U size
  - Custom backplane
  - Additional voltage supplies
    - +5V Digital, +- 12V Analog, +-12 V Bulk(Unfiltered)
- Fermilab/BiRa 4877 module
  - Cockroft-Walton generator
  - Six modules per VME crate
  - 8 channels per module
  - 10 voltage generator pod types
  - Backplane trip links
  - Backplane module address encoding (geographical)

Hardware

- Reference
  - Bi Ra - “Model VME 4877PS High Voltage Power Supply System Manual”

EPICS High Voltage Support



January 22, 2003

HV Record

- HV Record - hv
  - High-level device interface
  - Sequential state machine model (limited implementation of Harel state diagram)
  - Ramp algorithm
    - Parabolic end sections
    - Linear center section
  - Convergence algorithm
    - Repeat ramp until within tolerance limit
    - Enter PAUSE state if repeat limit exceeded

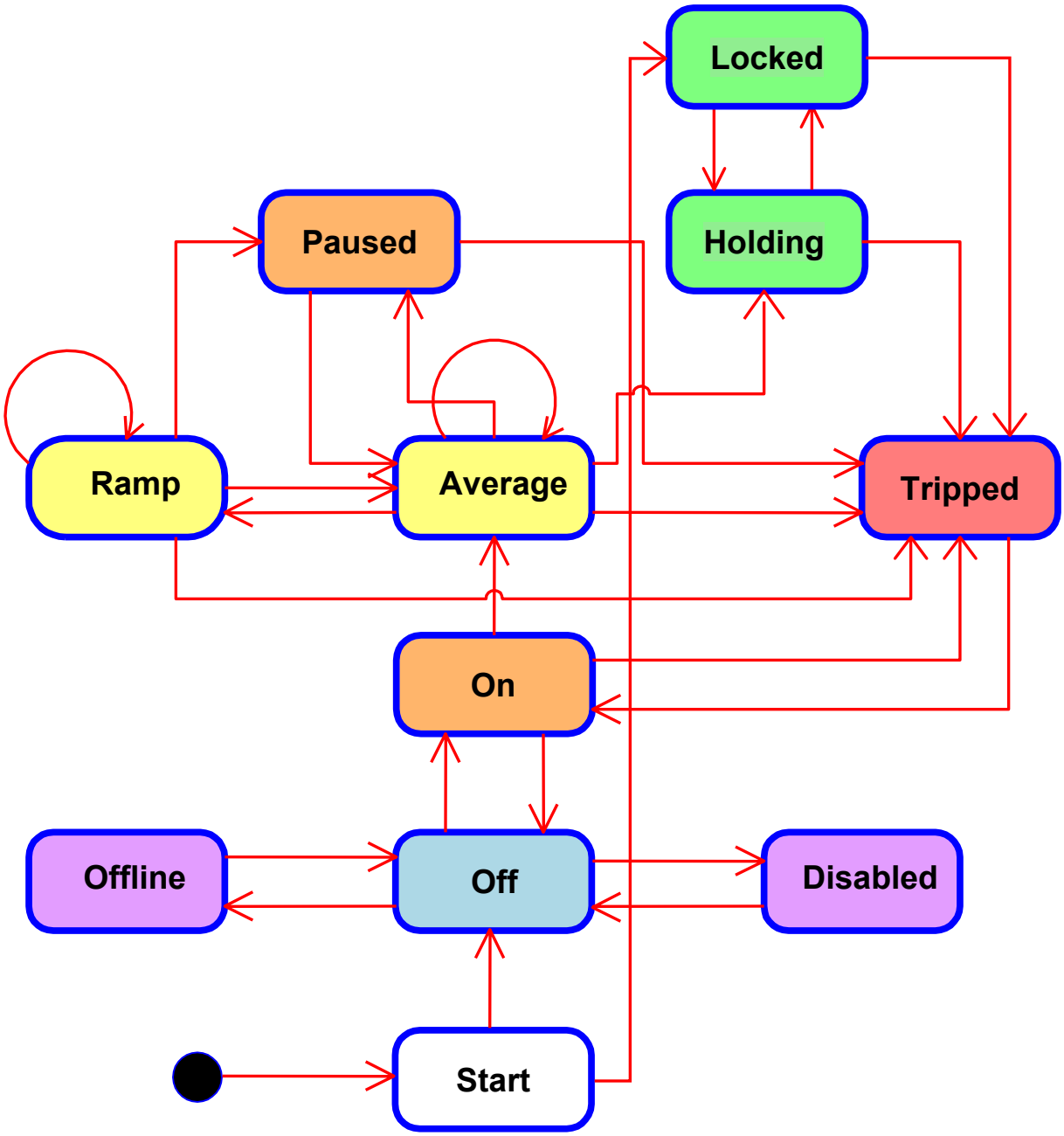
HV Record

- Purpose
  - Control and monitor an individual HV channel
  - Add high-level operations to a basic voltage generator
- Implemented as a sequential state machine with states, transitions, actions, and events
- Ramping to a target voltage is a software function

HV Record - Pod Types

Pod Name	Max Voltage	Max Current
P5.5KV1	+5.5kV	2.3 mA
M5.5KV1	-5.5 kV	2.3 mA
P5.5KV2	+5.5 kV	1.0 mA
M5.5KV2	-5.5 kV	1.0 mA
P5.5KV3	+5.5 kV	0.1 MA
M5.5KV3	-5.5 kV	0.1 mA
P3.5KV	+3.5 kV	3.5 mA
M3.5KV	-3.5kV	3.5 mA
P2.0KV	+2.0 kV	3.2 mA
M10V1	-10 V	0.2 mA

HV Record - State Diagram



HV Record - Ramp Algorithm

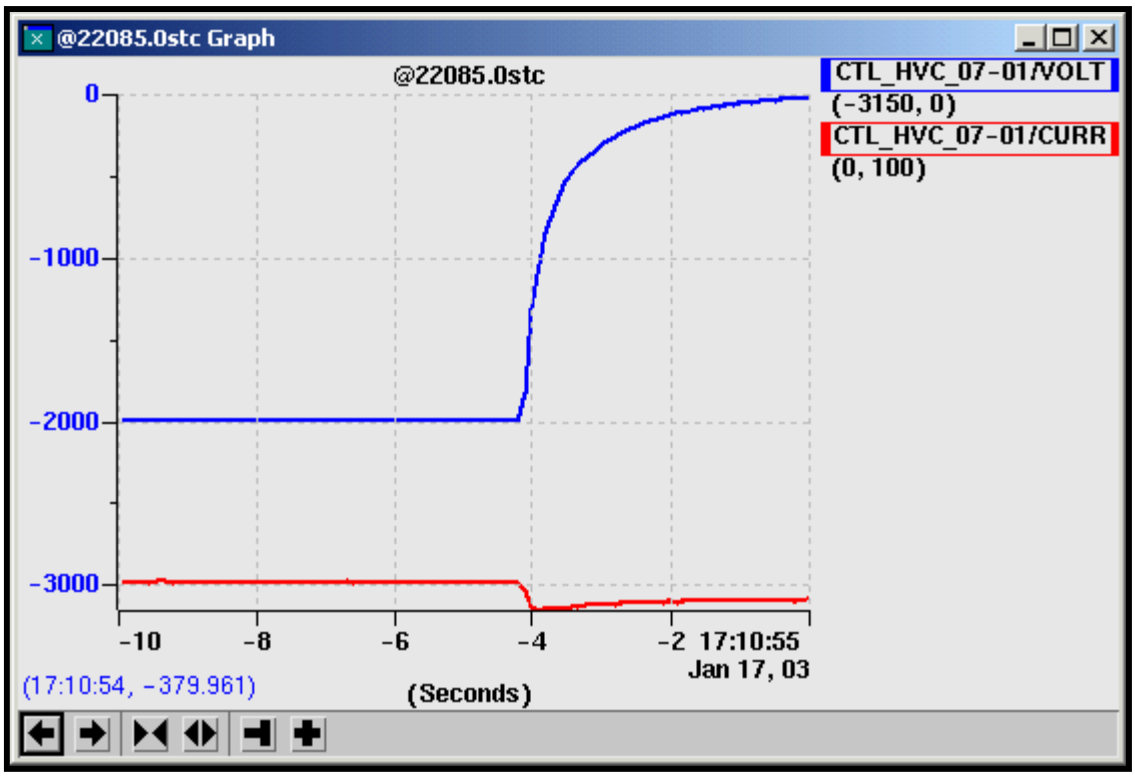
- Compute average voltage
- Compute voltage step size and number of steps to reach target voltage
- Execute ramp steps
- Compute average voltage
- Compare abs($V_{average}$ - V_{target}) with $V_{tolerance}$
  - less or equal - Enter HOLDING state
  - greater - Repeat ramp sequence

HV Record - Ramp Algorithm

- If the number of ramp cycles exceeds the limit, enter the PAUSE state and set an alarm condition

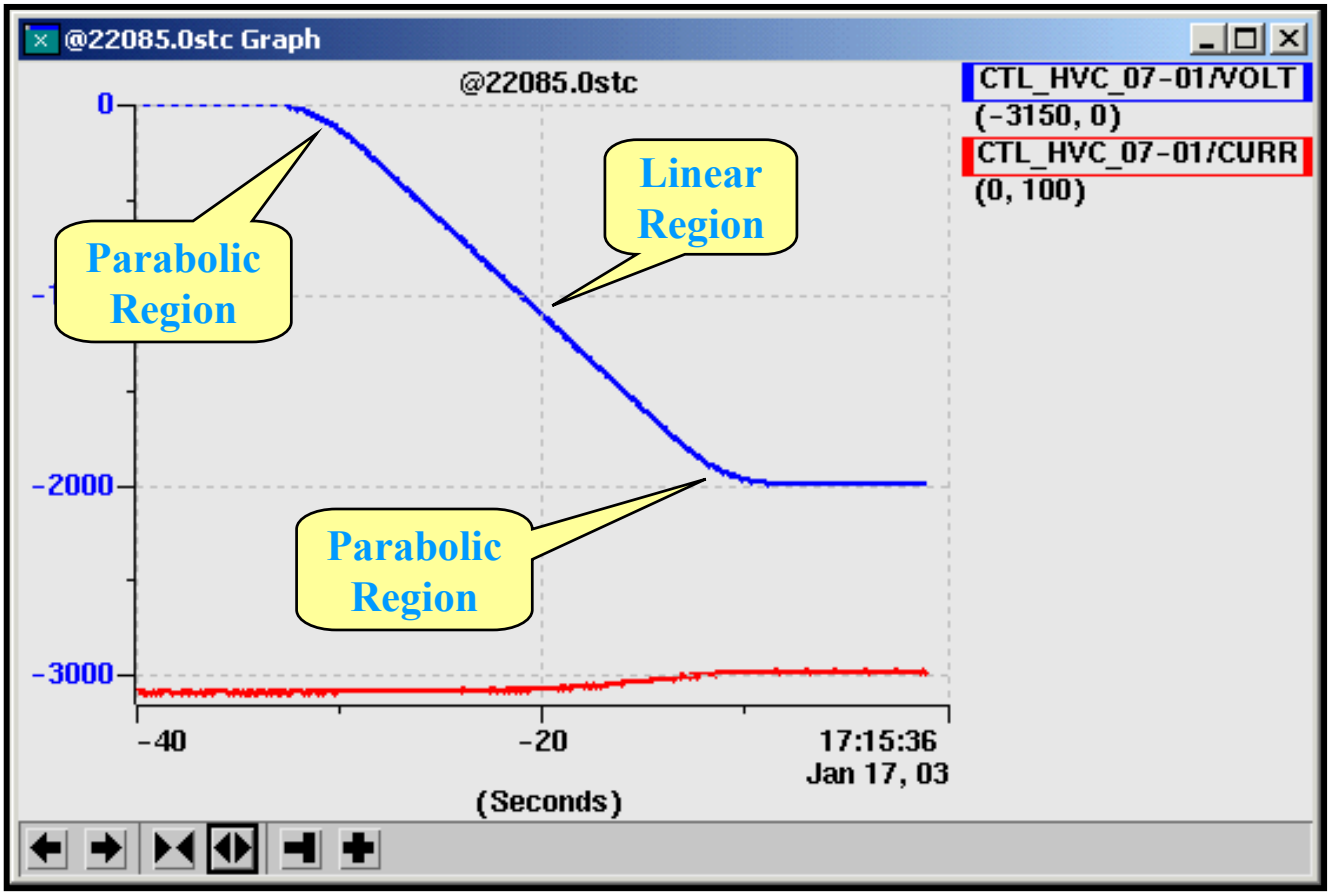
HV Record – Time Plots

- Decay profile
  - Capacitive load



HV Record – Time Plots

- Ramp regions
  - Parabolic ends
  - Linear center



HV Record - Trips

- Channel
  - Overvoltage
    - Trimpot setting
  - Overcurrent
    - Register setting
  - External
    - Backplane connection
- Module
  - Watchdog
    - Access timeout (unused)
  - Interlock
    - Front panel connector (unused)
  - External
    - Backplane connection

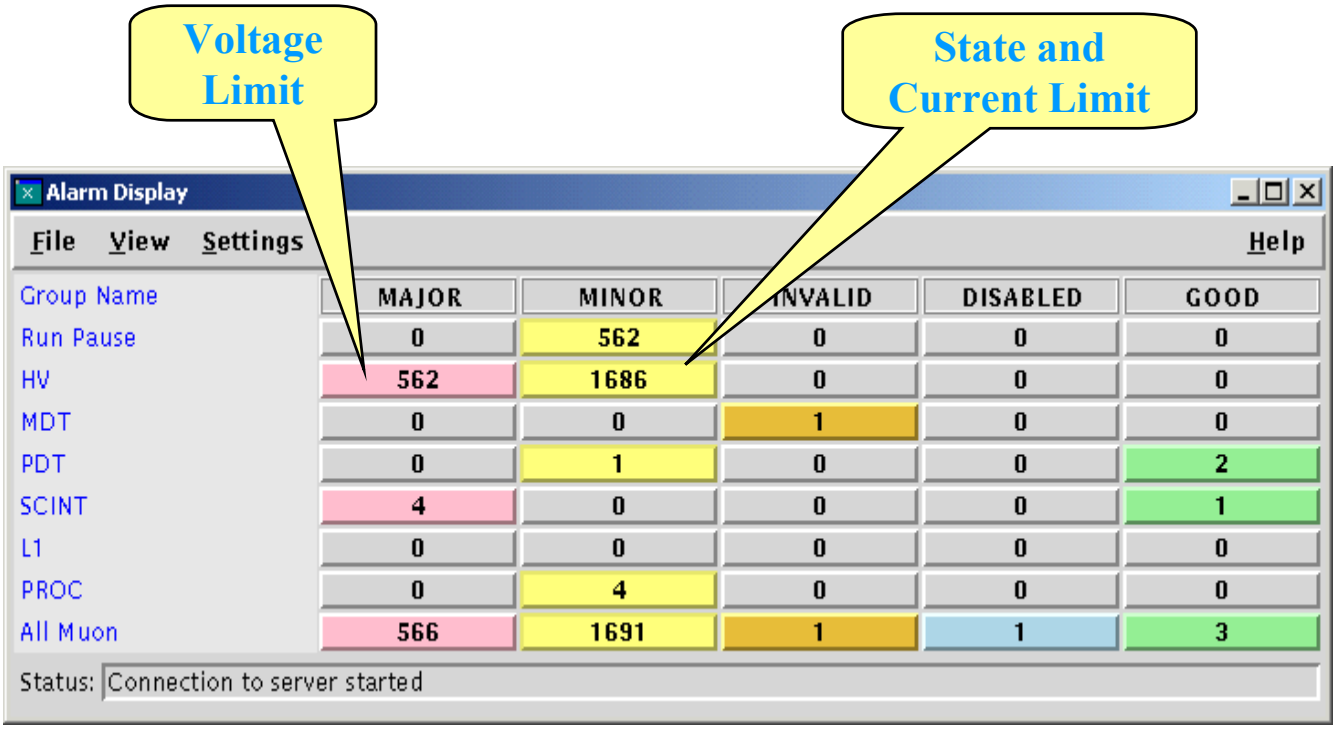
HV Record - Parameters

- ACCL
  - Parabolic acceleration rate (Volts/Sec**2)
    - RATE/ACCL = Duration of parabolic region (Sec)
- CSCAL
  - Ramping current scaling factor
- MAXC
  - Current trip level (uAmps)
- RATE
  - Ramp rate (Volts/Sec)
- VTOL
  - Voltage setting tolerance

HV Alarms

- **Invalid Alarm**
  - Hardware access error
  - OFFLINE or INVALID state
- **Minor Alarm**
  - OFF or PAUSED states
  - Current warning limit exceeded
  - Voltage warning limit exceeded
- **Major Alarm**
  - TRIPPED state
  - Current fatal limit exceeded
  - Voltage fatal limit exceeded
  - **A tripped channel will pause the run**

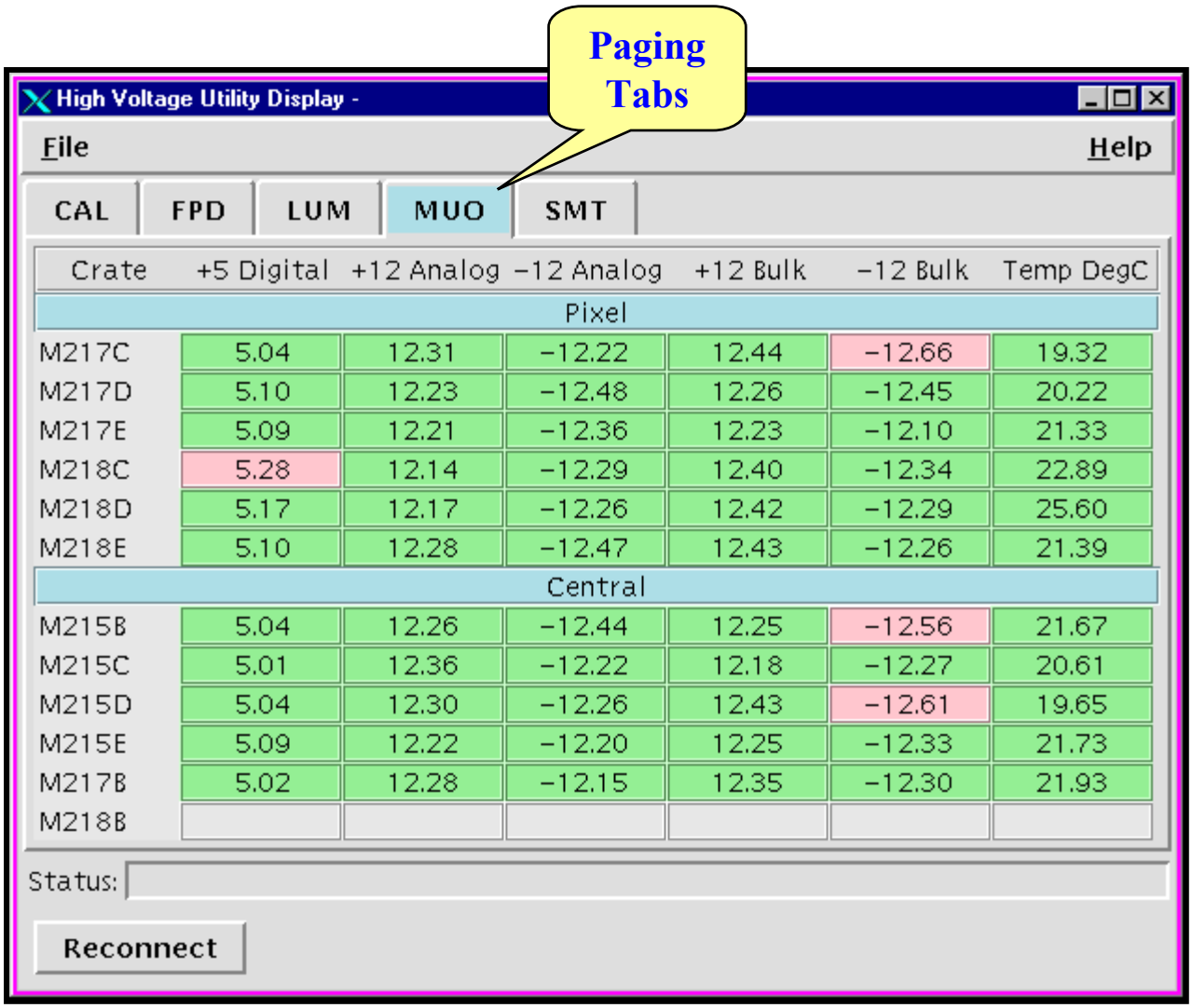
HV Alarms – SES Display



Operator GUI Programs

- HV Utility display
  - Monitor crate parameters (backplane voltages and temperature)
- Global HV display
  - Monitor channel state for multiple crates
  - Control state change for multiple crates
- HV Channel display
  - Monitor channel parameters for a single crate
  - Control state change for single channel or all channels in a crate

HV Utility Display

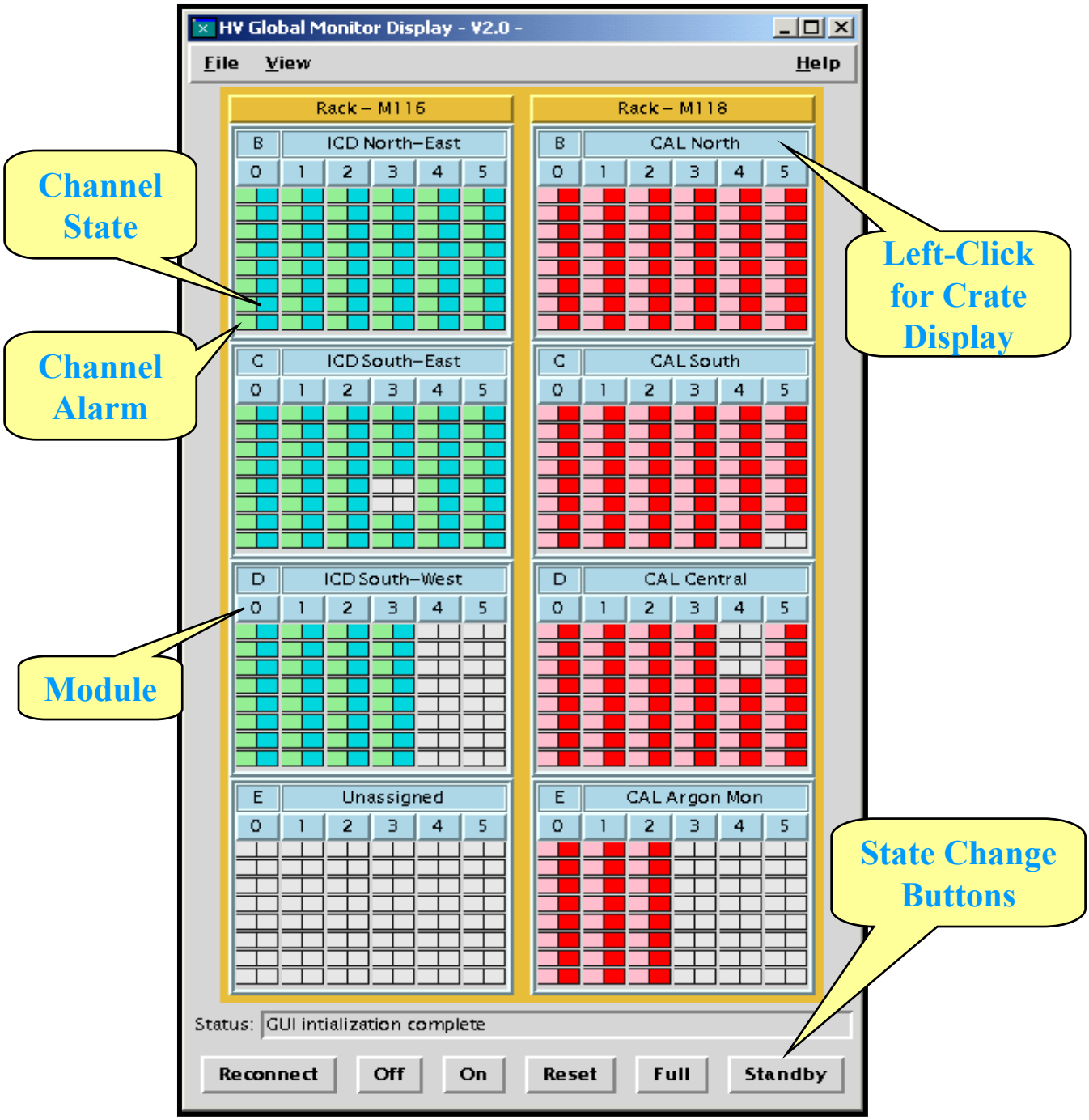


Crate	+5 Digital	+12 Analog	−12 Analog	+12 Bulk	−12 Bulk	Temp DegC
Pixel						
M217C	5.04	12.31	−12.22	12.44	−12.66	19.32
M217D	5.10	12.23	−12.48	12.26	−12.45	20.22
M217E	5.09	12.21	−12.36	12.23	−12.10	21.33
M218C	5.28	12.14	−12.29	12.40	−12.34	22.89
M218D	5.17	12.17	−12.26	12.42	−12.29	25.60
M218E	5.10	12.28	−12.47	12.43	−12.26	21.39
Central						
M215B	5.04	12.26	−12.44	12.25	−12.56	21.67
M215C	5.01	12.36	−12.22	12.18	−12.27	20.61
M215D	5.04	12.30	−12.26	12.43	−12.61	19.65
M215E	5.09	12.22	−12.20	12.25	−12.33	21.73
M217B	5.02	12.28	−12.15	12.35	−12.30	21.93
M218B						

HV Utility Display

- Purpose
  - Monitor HV crate parameters
    - Backplane voltages
    - Temperature
- Properties
  - Organized by detector page
  - Read-only access
  - Background color indicates alarm state
- Implementation
  - Python script
  - Program name - HvuGui.py
  - Configuration scripts - xxx.hvu

Global HV Display



Global HV Display

- Purpose
  - Monitor state of channels in multiple crates
  - Execute multiple-crate actions
  - Initiate crate display
- Properties
  - Organized by crate
  - Multi-crate action buttons
- Implementation
  - Python script
  - Program name - HvgGui.py
  - Configuration script - xxx.hvg

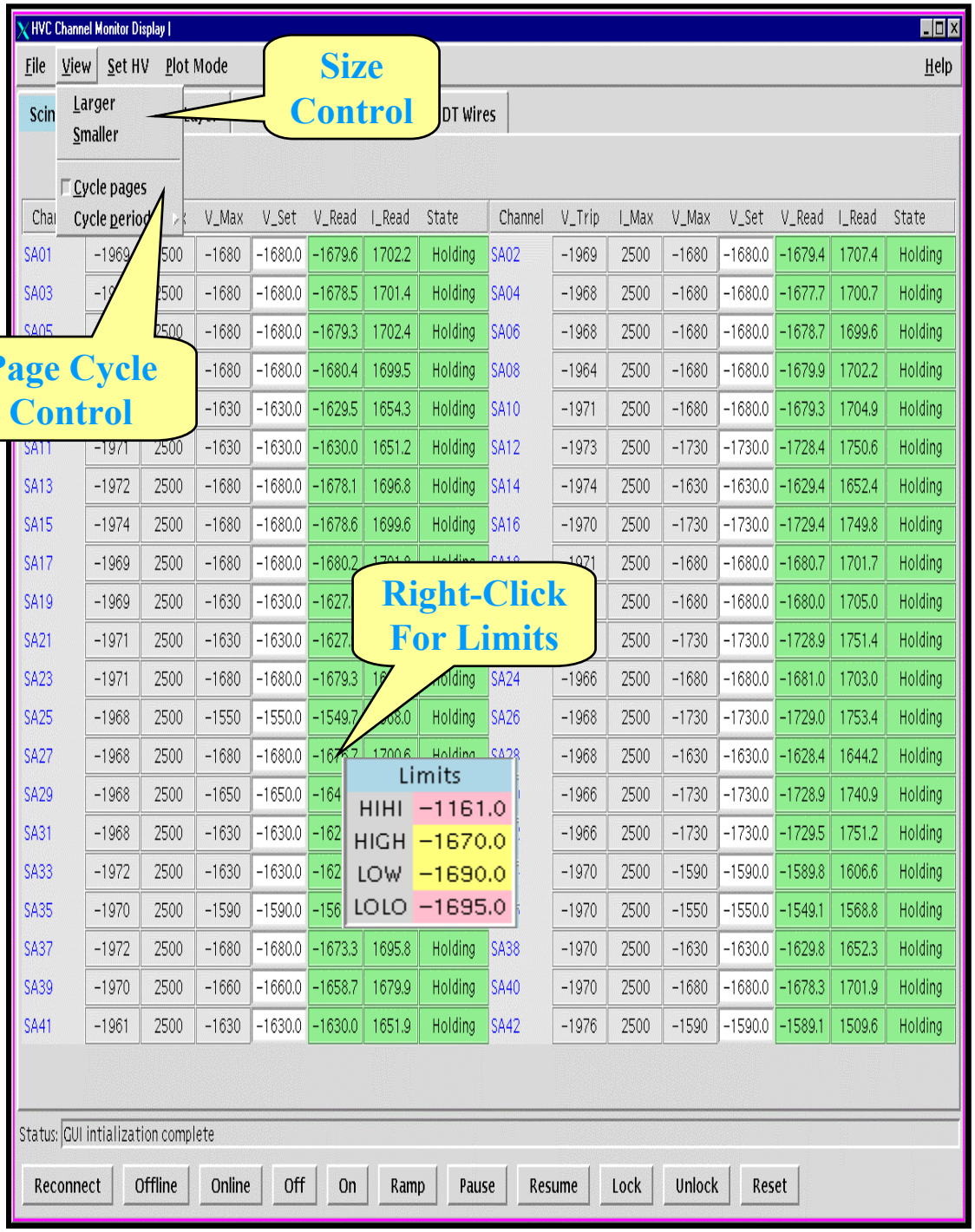
Global HV Display

- Crate button
  - Start individual crate display
- Action buttons
  - OFF - set channels to OFF state
  - ON - set channels to ON state
  - RESET - reset tripped channels
  - FULL - set to a full (operational) voltage
  - STANDBY – set to standby voltage

Global HV Display

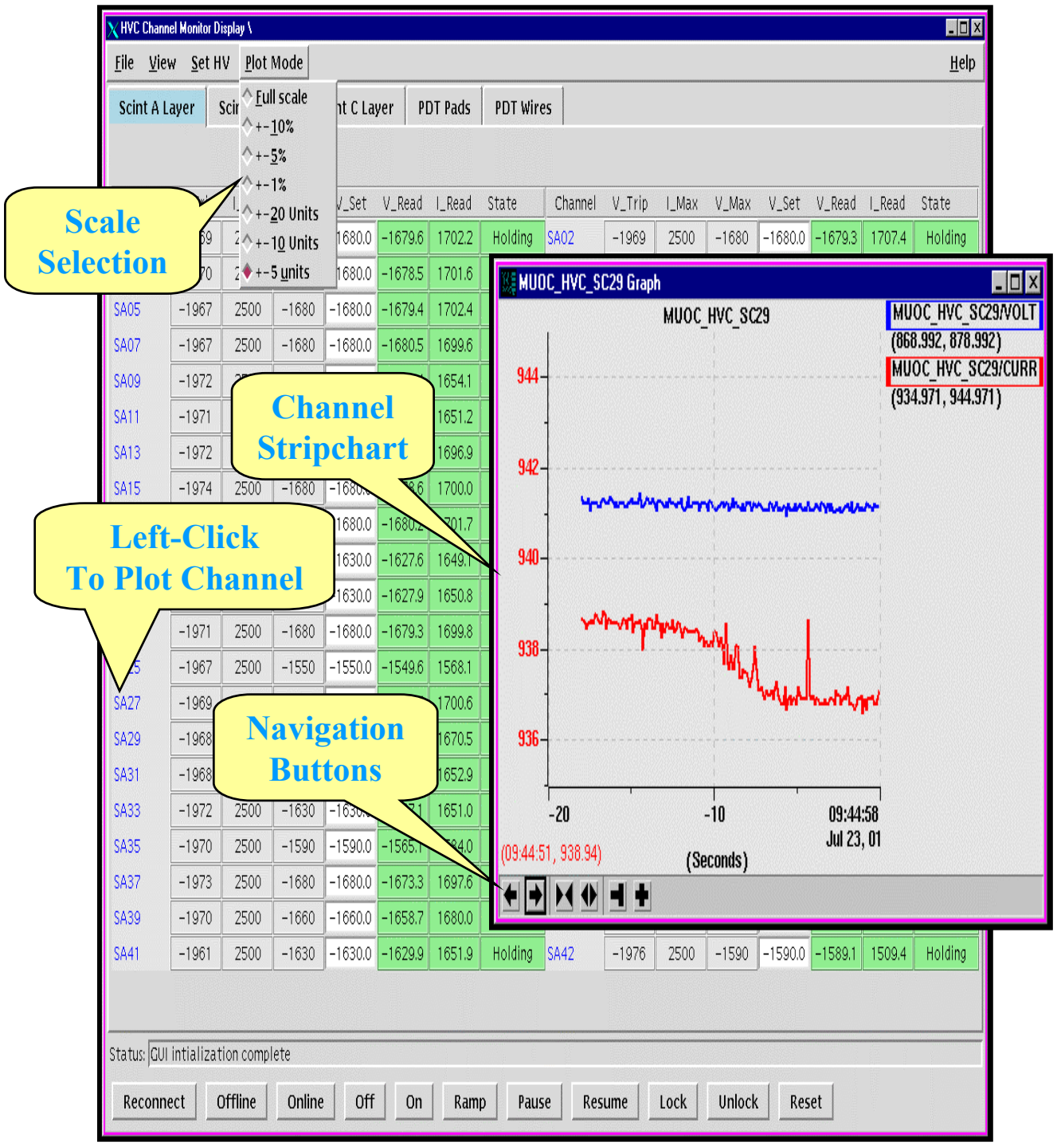
- Buttons for other target voltages may be added in the configuration file
- Channel state colors
  - Purple - OFFLINE, DISABLED
  - Blue - OFF
  - Orange – ON, PAUSED
  - Yellow - AVERAGE, RAMP
  - Green – HOLDING
  - Turquoise – LOCKED
  - Red - TRIPPED

HV Channel Display

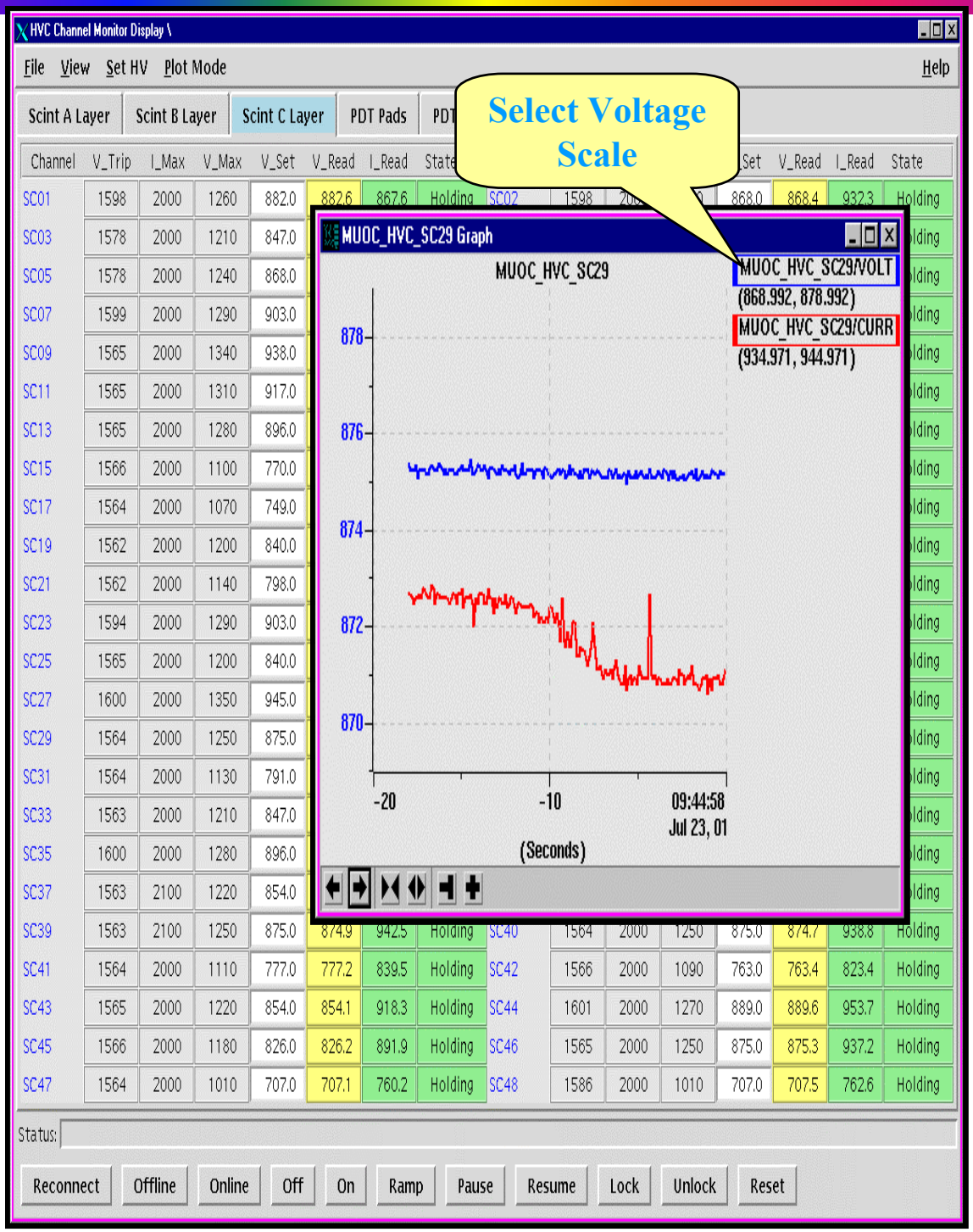


HV Channel Display

HV – Channel Display



HV Channel Display



HV Channel Display

HV Channel Display

- Purpose
  - Monitor individual channels
    - State
    - Voltage and current readback
    - Target voltage
    - Voltage and current trip levels
  - Execute all-channel and individual channel actions
  - Set all-channel and individual channel target voltages
  - Usually displays a single crate

HV Channel Display

- Properties
  - Organized by channel
  - Multi-channel action buttons
  - Channel action menu button
- Implementation
  - Python script
  - Program name - HvcGui.py
  - Configuration script - xxx.hvc
- Action buttons
  - Similar to global display +
    - OFFLINE/ONLINE
    - PAUSE/RESUME
    - LOCK/UNLOCK
- Channel state colors
  - Same as Detector display

Diagnostic Guidelines

- Channel is in offline state
  - Missing HV module
  - Incorrect module type in database
  - Faulty module
- Module trips after transition from off to on state
  - After a period with the power off, the channel may not be stable. Leave the power on for ~1/4 hour, after which the channel may recover.
  - Faulty module

Diagnostic Guidelines

- Module trips during ramp but has not exceeded either the voltage or current trip limit
  - After a period in the off state, the channel may not be stable. Leave the channel in the on state at zero output for ~1/4 hour, after which the channel may recover
  - Faulty module

Diagnostic Guidelines

- Ramp away from zero volts does not converge to target voltage
  - Record tuning parameters set incorrectly
  - Faulty module
- Current trip during ramp caused by capacitance charging
  - Reduce ramp rate
  - Increase current scaling factor parameter
  - Lengthen parabolic ramp region

Diagnostic Guidelines

- Ramp toward zero volts does converges to the target voltage very slowly
  - Reduce load capacitance or increase shunt resistance
    - The Cockroft-Walton generator is a charge pump and can only drive the voltage away from zero (positive or negative). Ramping toward zero requires a shunt resistance to discharge the load capacitance and the voltage divider resistance in the pod is ~10-50 Megohms.